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Manure Irrigation: Environmental Benefits, Potential Human Health Risks

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Farmers in Wisconsin and in many other states are increasingly embracing the practice of manure irrigation to fertilize their fields.[1,2] Spraying liquid manure on fields offers multiple environmental benefits, but it may also pose a threat to the health and well-being of people nearby. In a new study in *Environmental Health Perspectives*, a team of Wisconsin researchers estimated the risk of acute gastrointestinal infection associated with this emerging exposure pathway to potentially harmful pathogens.[3]

Irrigation provides an alternative to trucking manure onto farm fields. Manure may be liquefied by mixing it with animal urine or with wash water from the farm, or by processing it in an anaerobic digester to remove solids. Irrigation generally entails pumping this liquefied manure from a storage basin and onto fields via conventional water-irrigation equipment such as "center pivots," which spray in a 360° arc from a central point, or "traveling guns," which use a large nozzle to spray manure in a 180° arc while they are pulled across a field.[1]

Environmental benefits associated with manure irrigation include reduced vehicle emissions and wear and tear on roads because the liquid is transported by pipeline instead of by tanker truck. Irrigation also lets farmers maximize nutrient uptake by crops with the potential to minimize releases of nitrogen, phosphorus, and potassium through runoff and possible groundwater contamination, says study coauthor Rebecca Larson of the University of Wisconsin–Madison.

Larson explains that nutrient uptake by plants is not consistent through the growing season. "Generally, the more an applicator can tailor nutrient applications to a plant's uptake periods, the fewer nutrients will be lost," she says. Manure is typically applied to fields in the spring and fall, periods that do not coincide with plant nutrient uptake. By contrast, spray irrigation can occur throughout the year for more effective crop fertilization.

However, spraying liquid manure through an irrigation nozzle can also result in zoonotic microorganisms becoming airborne,

Spraying liquid manure through an irrigation nozzle can cause zoonotic microorganisms to become airborne. The aerosolized manure droplets and any pathogens they carry may drift to nearby homes and other unintended areas. Human exposure could lead to acute gastrointestinal illness. Image: © Mark Borchardt/USDA-ARS.

increasing the likelihood of humans coming into contact with them. Pathogens in the aerosolized manure could thereby infect humans, leading to adverse health effects, such as acute gastrointestinal illness.[4]

The growing popularity of manure irrigation among Wisconsin dairy farmers and coincident concern from citizens[5] led faculty from the University of Wisconsin–Extension to develop a workgroup composed of representatives from the state Department of Natural Resources and other partners.[6] The group was tasked with reviewing a broad set of issues associated with manure irrigation, including not only pathogen transport but also odor, water quality, and the drift of manure droplets to unintended areas. They also developed policy recommendations for state and local agencies. With these efforts, Wisconsin seeks to join at least 12 other states that have already developed guidance documents on manure irrigation.[1]

The new paper describes a multiyear study designed to assess potential human health risks associated with aerosolized pathogens. Between 2012 and 2014, the researchers tested the air during 21 separate irrigation events on three Wisconsin dairy farms, measuring manure-related microbes downwind of sprayers at distances of 100, 200, 350, 500, and 700 ft. They also recorded meteorological data to evaluate relationships among exposure, risk, and variables such as temperature, humidity, and wind speed.

Zoonotic pathogens of concern, including *Campylobacter jejuni*, enterohemorrhagic *Escherichia coli*, *Salmonella* spp., *Giardia lamblia*, and *Cryptosporidium parvum*, were rarely or never detected across the three farms. "Those three farms were probably particularly good with respect to preventing infections in their herds, which is why we did not find pathogens on them very often," Burch says. "However, ultimately we wanted risk estimates that could be generalized for any farm using spray irrigation, and not just for the three farms where we sampled." Therefore, the researchers used measurements of bovine *Bacteroides* and Gram-negative bacteria during manure irrigation as surrogates for the pathogens of interest.

The team modeled the air concentrations of the surrogates as a function of distance from the irrigation equipment, and they used previously published national data[7,8] on surrogate-to-pathogen ratios in manure to complete the risk assessment. Risk estimates varied depending on distance, wind speed, and other model parameters, as well as on which surrogate pathogen was used to estimate exposures, but the median values ranged between 1 in 10,000 and 1 in 100, depending on the model used.[3]

These estimated risks fall between acceptable levels of risk set by the U.S. Environmental Protection Agency for illnesses following contact with recreational water over a 30-day period (32 illnesses per 1,000 people)[9] and for illnesses due to exposure via drinking water over an entire year (1 in 10,000 people per year).[10] The authors also reported that airborne microbe concentrations increased with wind speed and that the estimated risks decreased with distance from the source.[3]

No national benchmarks exist for air levels of aerosolized microbes, leaving the results somewhat open to interpretation, says lead author Mark Borchardt, a research microbiologist with the U.S. Department of Agriculture's Agricultural Research Service (USDA-ARS). "We've laid out the distance–risk relationship and bracketed the degree of variability around those estimates," he says. "It really is a societal decision as to what is acceptable."

Fellow USDA-ARS research microbiologist John Brooks, who was not involved in the study, says he believes that the assessment may be fairly conservative—meaning that it overestimates risk—owing to assumptions the authors made about surrogate bacteria and relative rates of ingestion versus inhalation of airborne pathogens. Nevertheless, Brooks says, the study is unusually robust within the aerosol field because of its large number of samples.

The study did not address other potential routes of human exposure to zoonotic pathogens associated with manure irrigation. These routes include insect and animal vectors and deposition on surfaces that humans may touch or eat—particularly the skins of fruits and vegetables that are not washed or processed before consumption.

Yet the study represents an "important and thoughtful" contribution with direct implications for public health policy, says Keeve Nachman, an assistant professor of environmental health and engineering at the Johns Hopkins Bloomberg School of Public Health. "There is not a lot of research in this domain with spray irrigation of animal manures," says Nachman, who was not associated with the study. "These sorts of studies can help in the permitting process for the placement of sites and setbacks for houses and schools. This study is a helpful step towards trying to make decisions about what those distances should be."

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References

1. Genskow KD, Larson RA, eds. 2016. "Considerations for the Use of Manure Irrigation Practices: Report from the Wisconsin Manure Irrigation Workgroup." Publication Number ERC 001-16. Madison, WI:University of Wisconsin–Extension and UW–Madison College of Agricultural and Life Sciences, Environmental Resources Center. https://fyi.uwex.edu/manureirrigation/files/2017/04/Manure-Irrigation-Workgroup-Report-2016.pdf [accessed 1 October 2017].
2. Borchardt MA, Burch TR. 2016. "Airborne pathogens from dairy manure aerial irrigation and the human health risk." Madison, WI:U.S. Department of Agriculture Dairy Forage Research Center. https://pubs.er.usgs.gov/publication/70178035 [accessed 1 October 2017].
3. Burch TR, Spencer SK, Stokdyk JP, Kieke BA Jr, Larson RA, Firnstahl DA, et al. 2017. Quantitative microbial risk assessment for spray irrigation of dairy manure based on an empirical fate and transport model. Environ Health Perspect 125(8):087009, PMID: 28885976, https://doi.org/10.1289/EHP283.
4. Katzenelson E, Teltch B. 1976. Dispersion of enteric bacteria by spray irrigation. J Water Pollut Control Fed 48(4):710–716.
5. Seely R. 2014. Manure spraying under scrutiny. *WisconsinWatch.org*. Madison, WI; 27 April 2014. http://wisconsinwatch.org/2014/04/manure-spraying-under-scrutiny/ [accessed 1 October 2017].
6. University of Wisconsin–Extension. 2017. Understanding manure irrigation. http://fyi.uwex.edu/manureirrigation/ [accessed 1 October 2017].
7. U.S. Department of Agriculture (USDA), Animal and Plant Health Inspection Service (APHIS). 2003. *Escherichia coli* O157 on U.S. dairy operations. https://www.aphis.usda.gov/animal_health/nahms/dairy/downloads/dairy02/Dairy02_is_Ecoli.pdf [accessed 1 October 2017].
8. USDA, APHIS. 2011. Dairy 2007: *Salmonella*, *Listeria*, and *Campylobacter* on U.S. dairy operations, 1996–2007. https://www.aphis.usda.gov/animal_health/nahms/dairy/downloads/dairy07/Dairy07_ir_Food_safety.pdf [accessed 1 October 2017].
9. U.S. Environmental Protection Agency (EPA). 2012. Recreational water quality criteria. Docket No. EPA-OW-2011-0466, FRL 9756-2. Fed Reg 77(230):71191–71192. https://www.federalregister.gov/documents/2012/11/29/2012-28909/2012-recreational-water-quality-criteria [accessed 1 October 2017].
10. U.S. EPA. 1992. Risk of Microbial Risk Assessment in Setting U.S. Drinking Water Standards. EPA 814/S-92-001. Washington, DC:U.S. Environmental Protection Agency, Office of Water.